

ANTENNAL SENSILLA OF THE CHINESE LANTERN FLY,  
*PYROPS CANDELARIA* L. (HOMOPTERA: FULGORIDAE)

GERALD T. BAKER AND ANGSUMARN CHANDRAPATYA

(GTB) Department of Entomology, Mississippi State University, P.O. Drawer EM, Mississippi State, Mississippi 39762, U.S.A.: (AC) Department of Entomology, Kasetsart University, Bangkok, 10900, Thailand.

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*Abstract.* — The antennal pedicel of *Pyrops candelaria* has four types of sensory receptors: sensilla basiconica, sensilla campaniformia, sensilla chaetica and plaque organs. Porous and multi-innervated, sensilla basiconica are situated among the plaque organs on the female and male antennae. Sensilla campaniformia occur individually or in pairs on the pedicel. A single, large and fluted sensillum chaeticum is situated on the apex of the pedicel near the flagellum. Plaque organs cover the surface of the pedicel. They vary in size and consist of a central portion of pitted cuticular folds that may or may not be branched. This central area is surrounded by guard setae. The amphora-shaped flagellum has a long extension and an opening that leads to an atrium. Three sensilla basiconica are situated on the atrial walls. Sensillum chaeticum is the only type of sensillum to be situated on the scape and about 20 of these sensilla form an encircling band around the scape.

*Key Words:* Homoptera, Fulgoridae, *Pyrops*, antenna, sensilla

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INTRODUCTION

*Pyrops candelaria* L., Chinese lantern fly, feeds on several horticulturally important plants such as longan, *Dimnocarpus longan* Lour., mango, *Mangifera indica* L., and litchi, *Litchi chinensis* Sonn., in China and southeast Asia. This very large homopteran (3-4 cm in length) at times can reach numbers at which it can do severe economic damage. Basically, the antenna consists of a scape, which is very flexible; a large, bulbous pedicel which is covered with plaque organs; and a flagellar annulus, which is amphora-shaped with a long slender extension.

The ultrastructure of the plaque organs was described by Lewis and Marshall (1970), Marshall and Lewis (1971), and Marshall (1973). Marshall and Lewis (1971) showed that the changes in plaque organ complexity are in accordance with the taxonomic clas-

sification of Fulgoroidea by Metcalf (1951). Since there is no current information about the other sensilla on the antennae of *P. candelaria*, this paper provides an account of the morphology, number, and distribution of sensilla that are found on the antennal annuli of *P. candelaria*.

MATERIALS AND METHODS

Specimens of *P. candelaria* were collected on longan trees at Su-won Farm Res. Station of Kasetsart University, Thailand. For transmission electron microscopy (TEM), antennae were fixed over-night in Karnovsky's fixative in cacodylate buffer, pH 7.2 at 4°C. After rinsing, the specimens were placed in 2% osmium tetroxide for 4 hours on ice. The specimens were then washed in distilled water, dehydrated in ethanol, and embedded in Spurr's low viscosity resin.

Thick sections (0.5  $\mu\text{m}$ ) were stained with toluidine blue for light microscopy and ultra-thin sections were stained with uranyl acetate and lead citrate for TEM. The sections were examined with a JEOL or Hitachi TEM scope at 60 kV.

For SEM, fixation and dehydration were the same, after which the antennae were critical-point dried. They were mounted on aluminum stubs with double-sided adhesive tape and coated with gold-palladium. The specimens were examined with a Cambridge S360 SEM at 20 kV. Some antennae were stained with crystal violet (Slifer 1960) or silver nitrate (Schafer and Sanchez 1976) to detect pores in cuticle of the sensilla. All measurements which are given in microns and counts of sensilla are given as a mean plus the range and are based upon 10 specimens.

### RESULTS

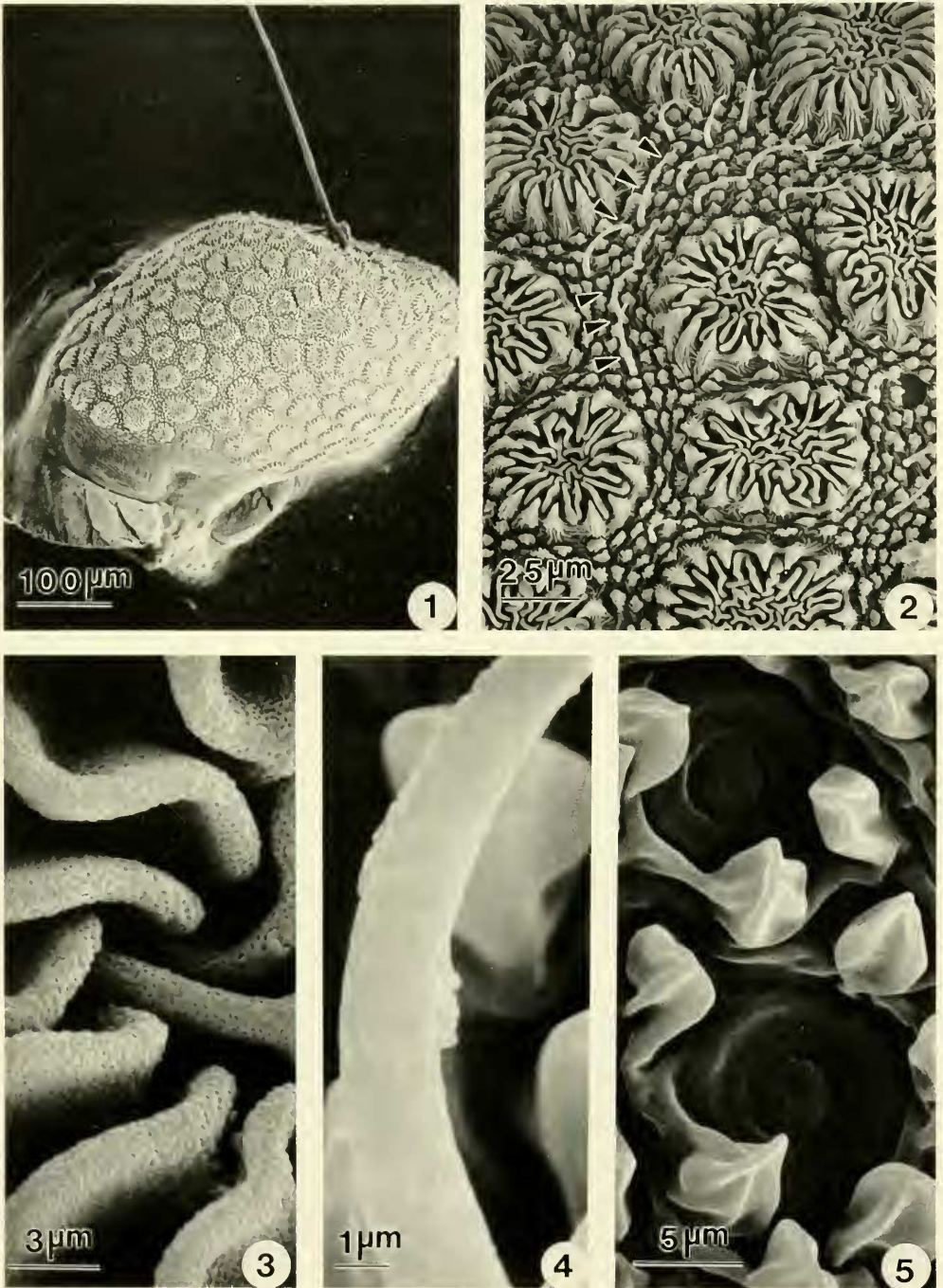
The pedicel, which is the largest, most obvious annulus and has the most sensilla, is a bulbous structure that measures 400 (385–410) wide at the base and 620 (605–635) wide at the apex in females and 390 (378–402) and 611 (601–619) in males (Fig. 1). Plaque organs cover the surface of the pedicel (Fig. 1). Between 168 and 190 plaque organs may be situated on the pedicel and no significant difference in total number of plaques exists between males 175 (168–183) and females 180 (174–190). Externally, each plaque consists of two distinct components, guard setae and the cuticular folds of the sensillum. (Fig. 2). The number of guard setae varies between 10 and 34 depending upon the diameter of the plaque. Guard setae are 16.5 (13–22) long and 10.5 (9–12) wide at the base and are longitudinally folded. They are situated on the periphery of the plaque and project inwards between the cuticular folds (Fig. 2). The guard setae appear to be a longer type of projection than the highly folded and shorter cuticular projections that cover the surface of the pedicel (Fig. 2).

The external portion of the plaque organ consists of deeply pitted cuticular folds that may or may not be branched (Fig. 3). These folds are 1.3 (0.8–2) wide, 13 (10–17) long and 5.2 (4–6) high. Most of the folds on the periphery of the plaques are unbranched and longer as compared to those in the central region which are branched and shorter. Plaque organs are 55 (24–81) in diameter. The distribution of the various size classes of plaques is random, i.e. small or large plaques are found on all areas of the pedicel. These sensilla stain intensely with crystal violet and silver nitrate, which indicates their porosity. The number of neurons associated with each plaque organ ranged from 128 to 152; based upon counts made from 0.5  $\mu\text{m}$  serial sections of 16 plaques.

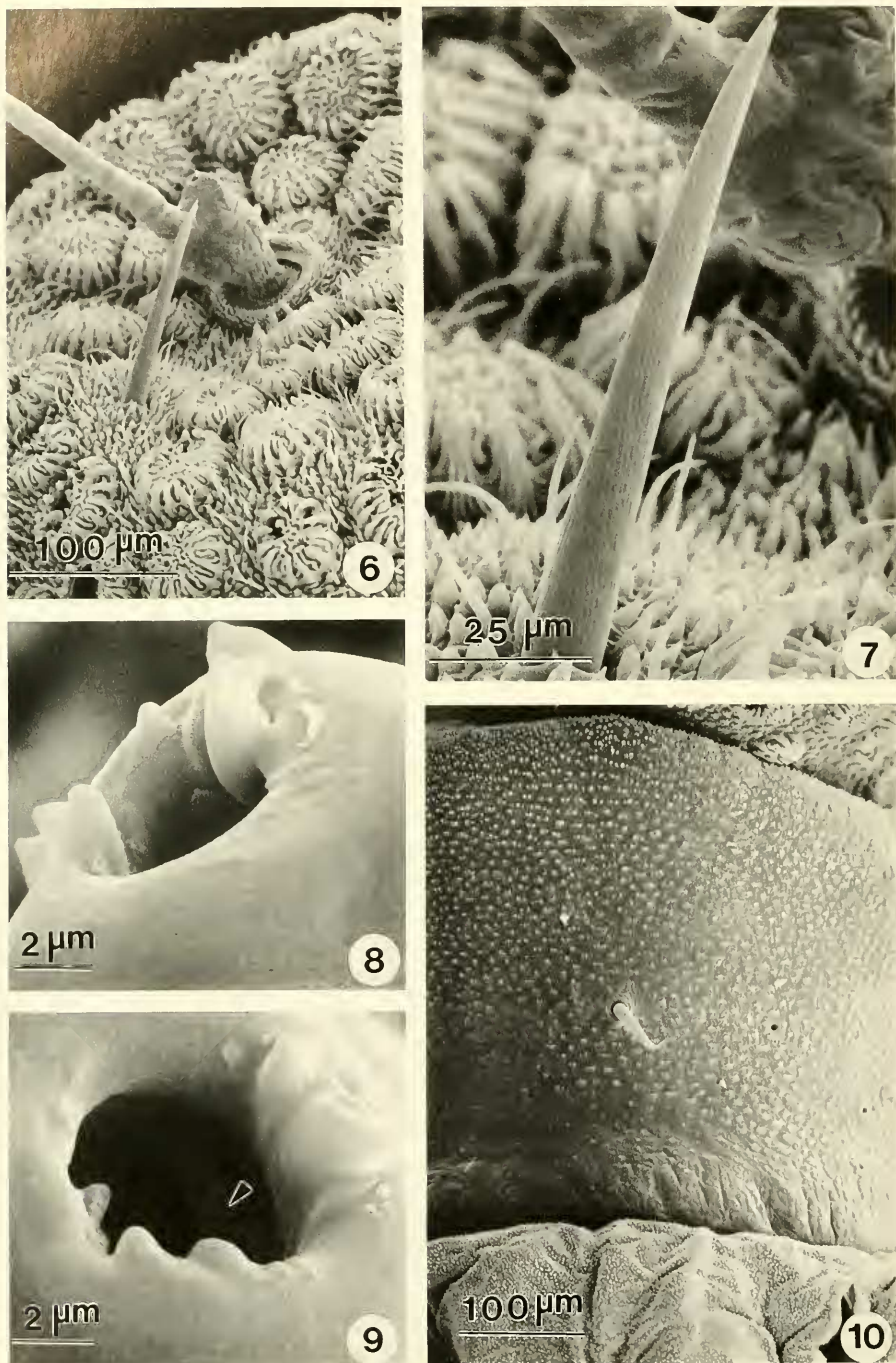
Sensilla *basiconica* are dispersed among the plaque organs and may be found as a single sensillum or in groups that range from 2 to 25 sensilla (Fig. 2). This sensillum is 27 (23–31) long and 3.6 (3.1–4.2) wide at the base. The shaft portion of the sensillum has a rough, pitted surface and is tapered and curved at the apex (Figs. 2, 4). It is hollow and porous, as indicated by the crystal violet and silver nitrate staining. Dendrites from the sensory neurons extend into the peg portion of the basiconic sensillum. There are 152 (140–164) of these sensilla on the pedicel.

The third type of sensillum that is situated on the pedicel is the sensillum *campaniformium*. This sensillum consists of a disc-like portion with a central pit and an area of raised cuticle that surrounds the disc-like portion (Fig. 5). The diameter is 9.7 (9.4–10.2) and they are located on various areas of the pedicel. Sensilla *campaniformia* occur as singles or doubles (Fig. 5) and do not stain with the crystal violet or silver nitrate.

A single, large sensillum *chaeticum* is the fourth type of sensillum on the pedicel, and it is situated on the apex of the pedicel near the flagellar annulus (Fig. 6). The sensillum is 110 (105–114) long and 14.6 (13.7–15.8)



Figs. 1–5. Sensilla on the pedicel of *P. candelaria*. 1. Plaque organs on the pedicel. 2. Sensilla basiconica (arrows) among the plaque organs. 3. Pitted cuticular folds of a plaque organ. 4. Surface of a sensillum basiconicum. 5. Two disc-like sensilla campaniformia.



Figs. 6-10. Antennal sensilla. 6. Sensillum chaeticum and flagellum on the apex of the pedicel. 7. Sensillum chaeticum with forked apex and fluted surface. 8 & 9. Cuticular extensions around the flagellar opening and basiconic sensillum (arrow) in the atrium. 10. Sensillum chaeticum on the scape.

wide at the base. The apex of the sensillum is forked, and the surface is fluted (Fig. 7). There was no staining of the sensillum by the crystal violet or silver nitrate.

The flagellum is composed of a single annulus that has two distinct portions, an amphora-like base and a long, slender, apical extension (Fig. 6). There is no evidence of any sensilla on the outer surface of the flagellum. An opening is situated on the apex of the amphora-like base (Fig. 8). This opening is 6.1 (5.2–7.3) in diameter and is surrounded partially by triangular, cuticular extensions (Fig. 9). The number, size, and shape of the extensions vary among the specimens (Figs. 8, 9). An atrium, which is irregularly shaped, is located beneath the opening and at its greatest width is approximately 9.5  $\mu\text{m}$ . There are three sensilla basiconica and two cuticular projections situated on the atrial wall (Fig. 11). These sensilla are 2.8  $\mu\text{m}$  (2.6–3.1  $\mu\text{m}$ ) long and 1.3  $\mu\text{m}$  (1.1–1.5  $\mu\text{m}$ ) wide at the base. The sensilla are hollow and fluted externally; dendrites from several sensory neurons occur in the hollow peg (Fig. 11).

Although the scape is the first antennal annulus, it is hidden by the bulbous pedicel. It is 405  $\mu\text{m}$  (390–415  $\mu\text{m}$ ) long and 250  $\mu\text{m}$  (238–259  $\mu\text{m}$ ) wide. Sensilla chaetica (22–27) are arranged in a band that encircles the scape. The sensillum is 48 (45–54) long and 9 (8–12) wide at the base (Fig. 10). The apical end is extended into a long, fine tip that is slightly curved, and the base is inserted into a socket of flexible cuticle. The outer surface of the sensillum is smooth. In cross section, this sensillum has a solid cuticular wall; no pores were indicated by the crystal violet and silver nitrate staining.

#### DISCUSSION

Lewis and Marshall (1970) presented a thorough and detailed description of the plaque organs on the antenna of *P. candelaria*. But there are some differences between their results and the information presented in this paper. First, the plaque differs

in the range of diameters, 26 to 80 versus 30 to 60 (Marshall and Lewis 1971) and in the number of guard setae surrounding, 10 to 34 versus 12–28 (Marshall and Lewis 1971). Second, the number of neurons in a plaque organ did not exceed 152 neurons and the average for the sixteen plaques was 137; this is less than the 200 to 300 given by Lewis and Marshall (1970). Third, Lewis and Marshall (1970) do not state anything about similarities or differences in the total number of plaques on female and male antennae. The male antennae have fewer plaque organs and this is probably due to the male pedicels being slightly smaller than the female pedicels.

The plaque organ on *P. candelaria* probably evolved from the coalescence of a group of sensilla basiconica (Lewis and Marshall 1970, Marshall and Lewis 1971). This plaque organ is not similar to the type found on the antennae of many different Hymenoptera (Esslen and Kaisling 1976, Borden et al. 1978a, b) and on the antennae of Sternorrhyncha (Homoptera) (Bromley et al. 1979, Slifer et al. 1964). Bourgoin (1985) is the only publication that provides a detailed description of the morphology, number, and distribution of the various types of sensilla that occur on fulgoroid antennae; he described those on several species from the family Tettigometridae (Homoptera: Fulgoroidea). Sensilla chaetica encircle the scape of *Tettigometra sulphurea* (Mulsant & Rey) just as in *P. candelaria*, but no sensilla basiconica are situated on the scape of *P. candelaria* as with *T. sulphurea* and other tettigometrids (Bourgoin 1985).

The number (35 plaques), distribution (few plaques on the ventral surface of the pedicel) and morphology (dome shaped plaques) of plaque organs on *T. sulphurea* pedicel differ greatly from the 168 to 190 plaques that cover all surfaces of the pedicel and are ridged and surrounded by guard setae on *P. candelaria*. Marshall and Lewis (1971) presented a gradation in complexity of plaque morphology and its correlation

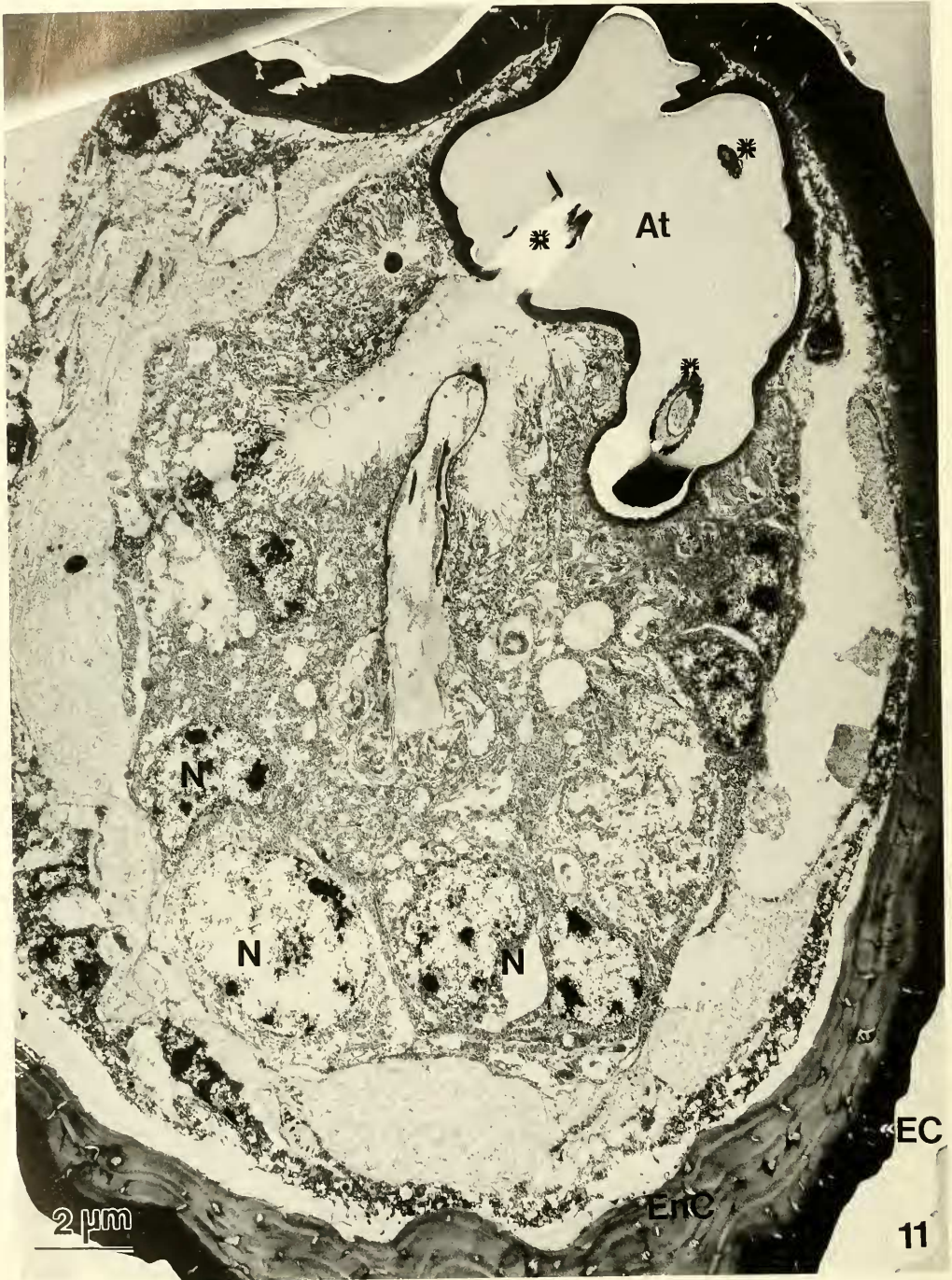


Fig. 11. Longitudinal section of the flagellum showing the internal atrium (A), three sensilla basiconica (asterisks), nuclei of perikarya (N) and thick cuticle (EC—exocuticle; EnC—endocuticle) of the flagellum.

with the taxonomic classification for the Fulgoroidea (Metcalf 1951). In their gradation diagram there is a blank slot for the subcohort Tettigometraia. Bourgoin's (1985) description of *T. sulphurea* plaques clearly places these structures into the vacant slot in the gradation scheme of plaque complexity in accordance with Metcalf's taxonomic classification. Sensilla ampulaca are present on the pedicel of *T. sulphurea* (Bourgoin 1985) but none occur on the pedicel of *P. candelaria*. Also, only one sensillum chaeticum is situated on the pedicel of *P. candelaria* whereas *T. sulphurea* has 32 (Bourgoin 1985). *Tettigometra sulphurea* has only 8 sensilla basiconica as compared to more than 140 on the pedicel of *P. candelaria*.

The flagellum on *P. candelaria* and *T. sulphurea* are basically the same shape and have the same components, an amphora-like base with an apical opening and a long, slender extension. Over 100 denticles surround the opening on the flagellum of *T. sulphurea* (Bourgoin 1985), whereas in *P. candelaria*, only 4 to 6 denticles are associated with the flagellar opening. At first, it appeared that the denticles on *P. candelaria* were a type of solidified excretion but the structures remained even after using solvents such as water, acetone, ethanol, methanol, chloroform and sodium hydroxide. There are two cuticular projections (non-innervated) and three sensilla that project from the atrial wall in *P. candelaria*, whereas *T. sulphurea* has two non-innervated cuticular projections and two cuticular sensory receptors (Bourgoin 1985).

No electrophysiological data for the various types of sensilla are available at the present time. The sensilla chaetica on the scape are probably involved in monitoring the position of the other antennal annuli in relation to the scape and the antennae to the head, whereas the large chaeticum on the pedicel may be monitoring the movement of the flagellum. Sensilla basiconica and plaque organs have the ultrastructural

characteristics of a chemoreceptor, and the sensilla campaniformia are involved in detecting cuticular stress in the bulbous pedicel (McIver 1975, Zacharuk 1980). Behavioral and electrophysiological data are needed to determine the functions of the sensilla on the pedicel and those inside the flagellar atrium.

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